Future Tends in Systems & Software Engineering

- How Future Trends Bode Well for Systems Engineering's Partnership in the Transformation

Second Annual Systems Engineering Conference
4 June 2008
National Reconnaissance Office
Chantilly, Virginia
Theme: Systems Engineering: A Partner in Transformation

Dr. Kenneth E. Nidiffer
Director of Strategic Plans for
Government Programs
nidiffer@nro.mil
nidiffer@sei.cmu.edu

Public reporting burden for the col maintaining the data needed, and c including suggestions for reducing VA 22202-4302. Respondents shot does not display a currently valid C	ompleting and reviewing the collect this burden, to Washington Headqu ald be aware that notwithstanding an	tion of information. Send comment parters Services, Directorate for Inf	s regarding this burden estimate ormation Operations and Reports	or any other aspect of the state of the stat	nis collection of information, Highway, Suite 1204, Arlington
1. REPORT DATE 04 JUN 2008	2 DEDORT TYPE			3. DATES COVERED 00-00-2008 to 00-00-2008	
4. TITLE AND SUBTITLE Future Tends in Systems & Software Engineering -How Future Trends Bode Well for Systems Engineering's Partnership in the Transformation				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Carnegie Mellon University ,Software Engineering Institute (SEI),Pittsburgh,PA,15213				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAIL Approved for publ		ion unlimited			
13. SUPPLEMENTARY NO	TES				
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFIC	ATION OF:		17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified	Same as Report (SAR)	28	KEST ONSIDLE FERSON

Report Documentation Page

Form Approved OMB No. 0704-0188

The Software Engineering Institute - Improving the State of Practice of Engineering: Create, Apply and Amplify

Federally Funded Research and Development Center

Created in 1984

Sponsored by the U.S. Department of Defense

Locations in Pittsburgh, PA; Washington, DC; Frankfurt, Germany

Operated by Carnegie Mellon University



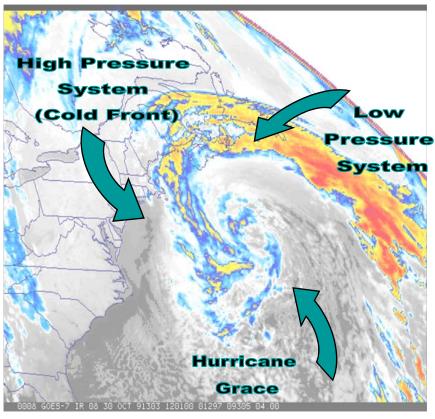




Overview



- Transformational Trends in Systems and Software Engineering
 - Development
 - Innovation
 - Integration
 - Human Element
 - Communications
 - Process
- Ten Trends
- Wrap-up



"Perfect Storm" Event, October 1991 National Oceanic & Atmospheric Administration

Development Challenges: Need for Space, Air, Ground, Water, Underwater Software-Intensive Systems that are Interconnected



- Several million SLOC programs; "Hybrid" systems combining legacy re-use, COTS, new development
- Multi-contractor teams using different processes; dispersed engineering, development & operational locations
- New technologies create opportunities/challenges; products change/evolve, corporations mutate
- Business/operational needs change often faster than full system capability can be implemented
- Skillset Shortfalls; Cost and schedule constraints
- Demands for increased integration, interoperability, system of system capabilities
- Enterprise perspectives/requirements; sustainment concerns



Systems Engineering – A
Partner in Developing More
Responsive Space Systems

© 2008 Carnegie Mellon University

Software Engineering Development Trends That Impact Systems Engineering



Traditional

- Standalone systems
- Mostly source code
- Requirements-driven
- Control over evolution
- Focus on software
- Stable requirements
- Premium on cost
- Staffing workable

Future

- Everything connected-maybe
- Mostly COTS components
- Requirements are emergent
- Limited control over COTS evolution
- Focus on systems and software
- Rapid change
- Premium on value, speed, quality
- Scarcity of critical talent

Emerging Dynamics of Bringing Systems and Software Engineering in Continued Partnership

The Acceleration of Innovation in the 21st Century: Impact Systems Engineering Transformational Activities



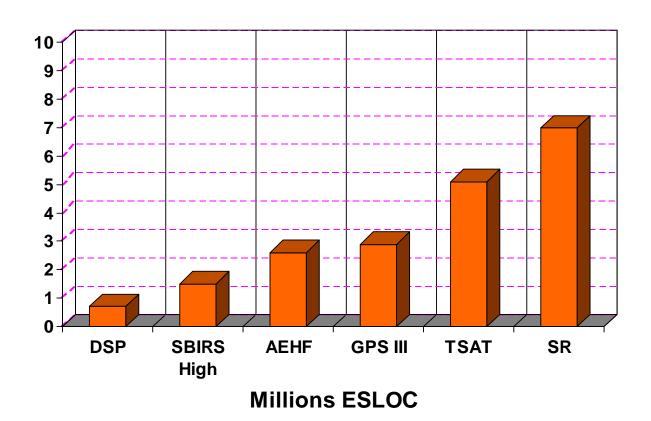


Dr. Kenneth E. Nidiffer

Growth Trend in Space System Software

(Onboard and Ground Software)



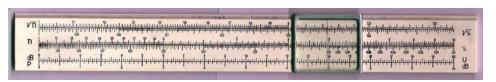




System/Software Engineering I/F Challenges: Augustine's Law - Growth of Software - Order of **Magnitude Every 10 Years**



In The Beginning





1960's



F-4A 1000 LOC



1970's



F-15A *50,000* LOC



1980's



F-16C 300K LOC



1990's



F-22 1.7M LOC





F-35 >6M LOC



System/Software I/F Challenges: Relationship **Between Complexity and Acquisition Success Improving But Not Enough!**



Software is Growing in Complexity

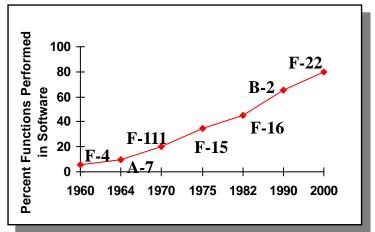
- 80% of some weapon system functionality is dependent upon software¹
- Consequences of software failure can be catastrophic

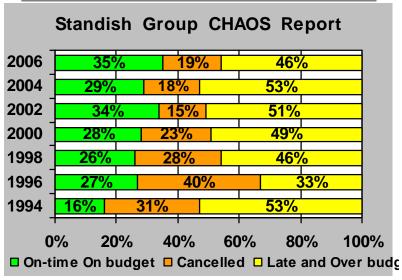
Software Acquisition is Difficult

- 46% are over-budget (by an average of 47%) or late (by an average of 72%)²
- "Successful projects" have 68% of specified features²

Software is Pervasive

 Space, IT Systems, C4ISR, Weapons, etc

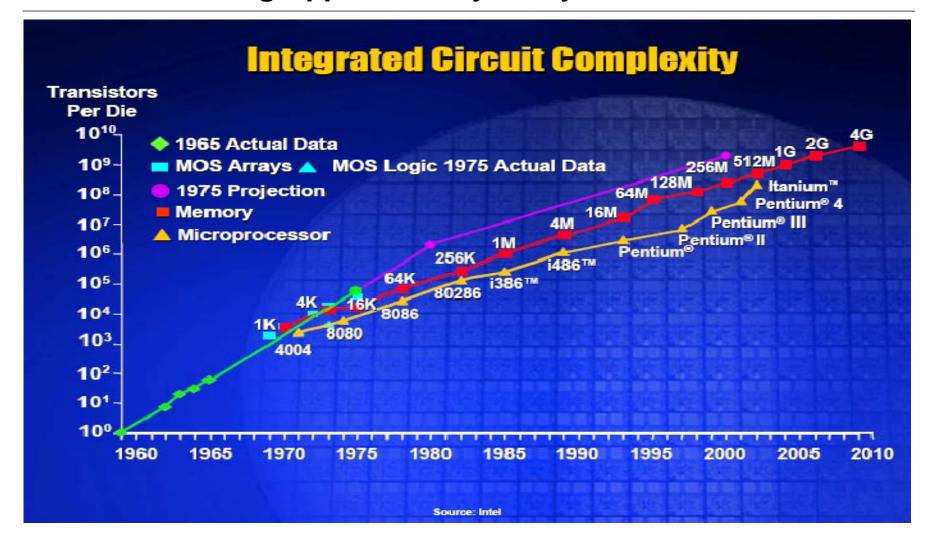






Carnegie Mellon

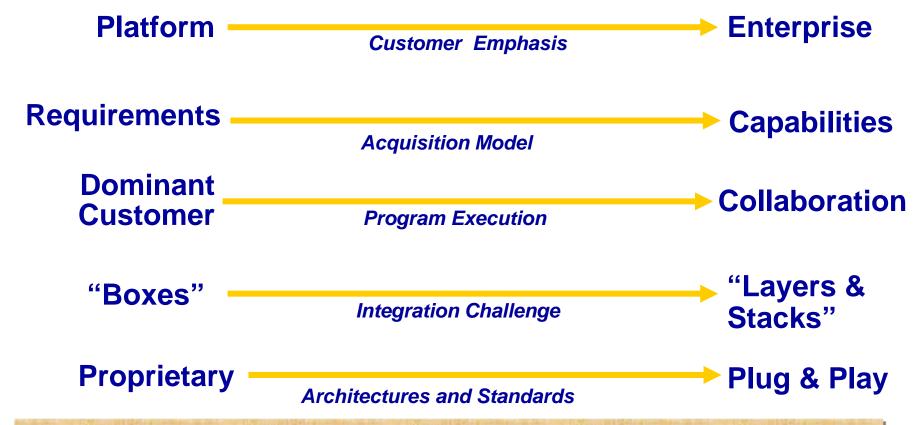
System/Hardware Engineering I/F Challenges - Moore's Law: The Number of Transistors That Can be Placed on an Integrated Circuit is Doubling Approximately Every Two Years





Systems Engineering Integration Challenges: Some Drivers That Increase the Complexity of Acquiring Systems





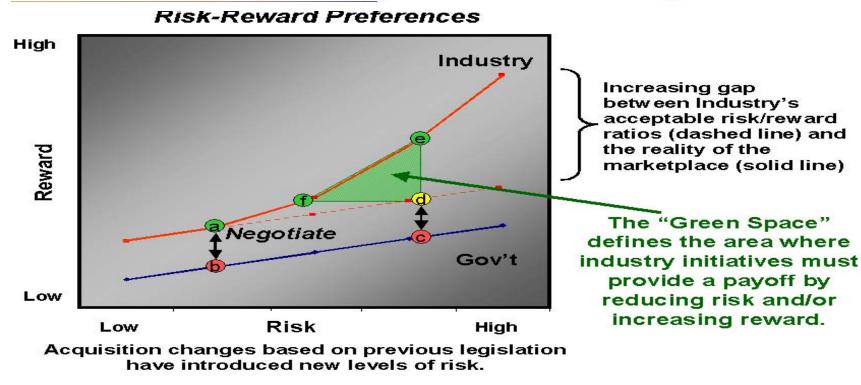
Transformation will require addressing both sides, and do so with compressed delivery schedules via improvements in systems/software engineering

© 2008 Carnegie Mellon University

Increased Reliance on Acquirer/Developer to Reduce Integration Risk by Effectively Navigating the Green/Acquisition Space



Navigating the "Green Space"

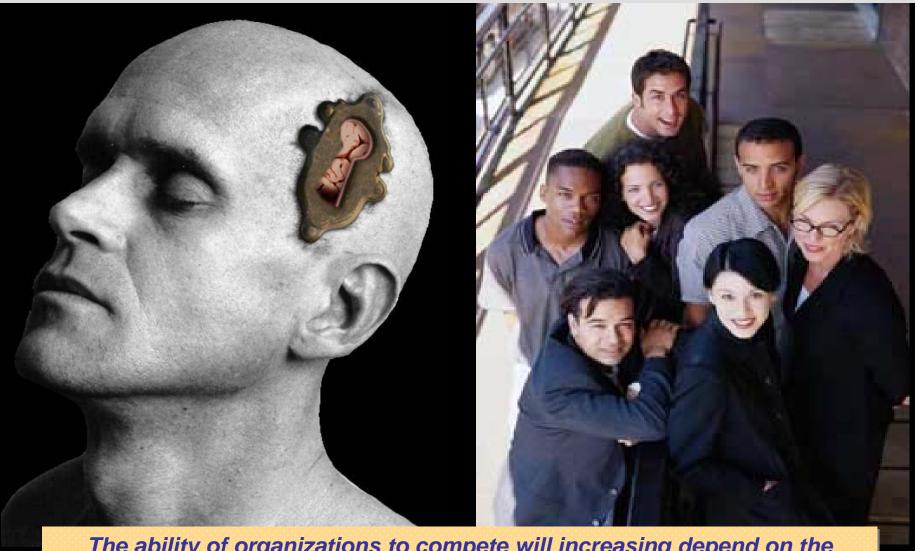


©2005 Systems and Software Consortium, Inc.

Source: Nidiffer and Dolan, IEEE Software, Sept/Oct 2005

Human Element – Perhaps the Longest Pole in the Tent Is Rebuilding the Workforce – Gen Thomas S. Moorman Jr. (Ret)

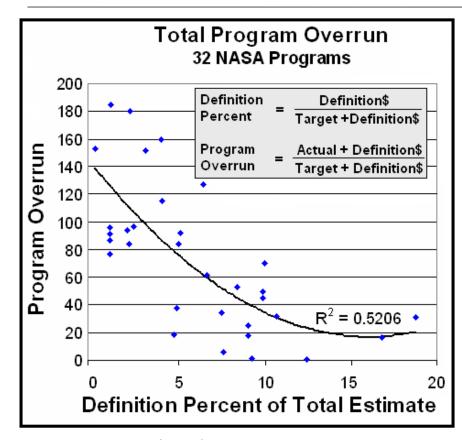
March 2008



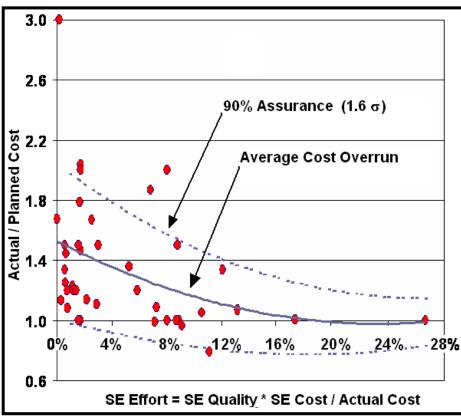
The ability of organizations to compete will increasing depend on the innovation of the human element

The Challenge - Supporting Evidence





Gruhl, Werner (1992), Lessons Learned: Cost/Schedule Assessment, Internal Presentation, NASA Comptroller's Office



Honour, Eric (2004), *Understanding the Value of Systems Engineering*, Proceedings of the 14th Annual INCOSE International Symposium

Systems Engineering Effectiveness Survey (2004-2007)

Hypothesis: The effective performance of SE best practices on a development program yields quantifiable improvements in the program execution (e.g., improved cost performance, schedule performance, technical performance).

Objectives:

- Characterize effective SE practices
- Correlate SE practices with measures of program performance

Approach:

- Distribute survey to NDIA companies
- SEI analysis and correlation of responses

Survey Areas:

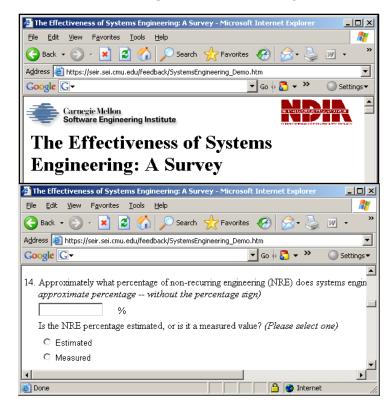
Process definition Trade studies

Project planning Interfaces

Risk management Product structure

Requirements development Product integration

Requirements management Test and verification

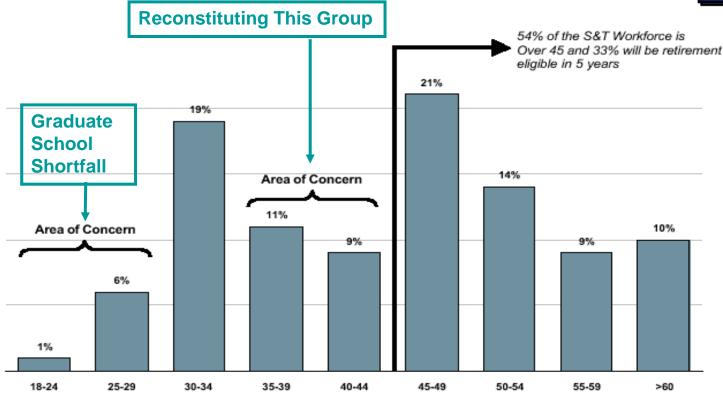


Configuration mgmt

Metrics

Society Drivers: Bimodal Demographics (Space Industry)





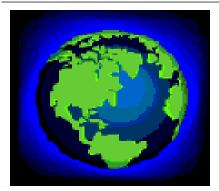
Average Space Industry S&E Workforce Age Distribution

Trend: Industry/Gov't Will Increasingly Focus on Attracting, Training and Retaining Systems Engineering Talent



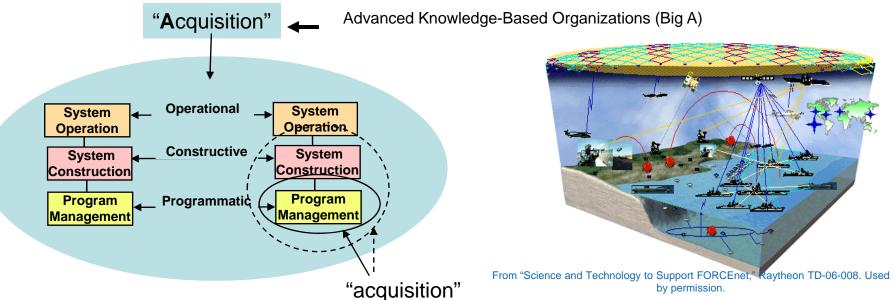
Organizational Performance - Flexible **Boundary-Crossing Acquisition Structure**





2005 study confirmed*:

- In advanced knowledge-based organizations, management's desire for the flow of knowledge is greater than the desire to control boundaries
- Unlike the matrix organization, there is less impact on the dynamics of formal power and control
- Using Communities of Practice to Drive Organizational Performance and Innovation, 2005, APQ study



Ref: Jim Smith, (703) 908-8221, jds@sei.cmu.edu

Human Element Challenge: Bumpy Road at the Systems Engineering/Software Engineering Intersection





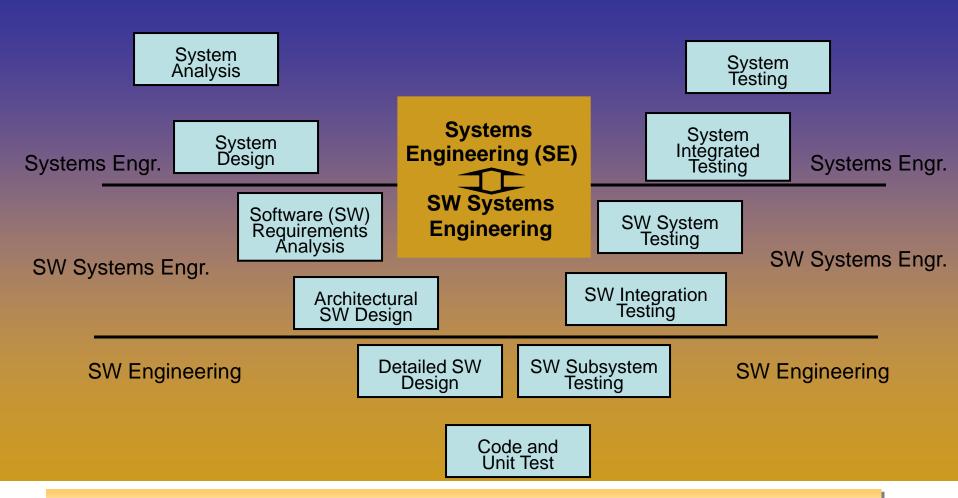
The Integration of Systems and Software Engineering will take SE Leadership
Commitment

Source: Kurstedt, Harold, Newport Group, 2008



Human Element: Current Objective is for Software and Systems Engineering to Become More Integrated Versus Separated



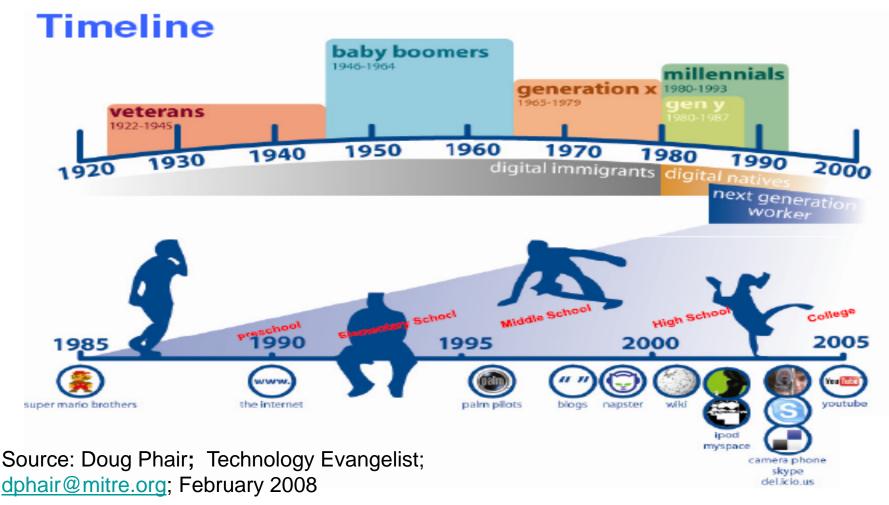


OSD Initiative: Integrated Software and Systems Engineering Curriculum



Human Element in the Work-Space Environment

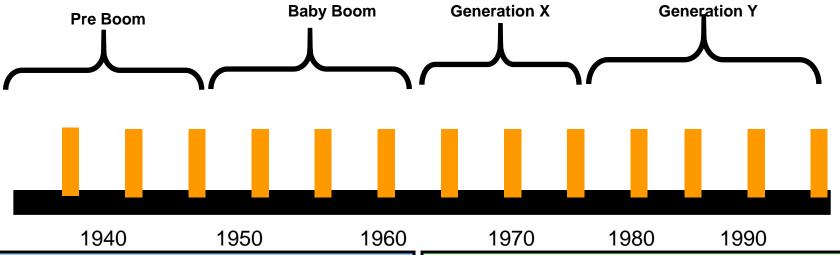




© 2008 Carnegie Mellon University

Human Element: More Generation Y Workers Will Enter the Workplace





Generation Y Characteristics

- Born late 1970s to mid-1990s
- Larger than Generation X
- More ethnically diverse
- Technologically savvy

What Makes Generation Y Tick

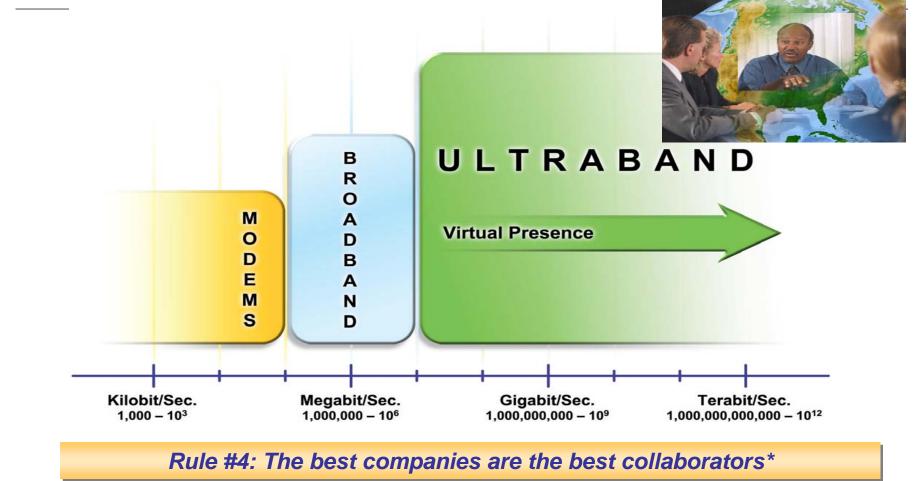
- High Expectation of Employers
- Goals, Goals
- Desire for Immediate Responsibility
- Balance and Flexibility

Source: Cara Spiro, DAU, 2006



Increased Capabilities in the Digital Spectrum Enables SE Improvements in Communication and Collaboration



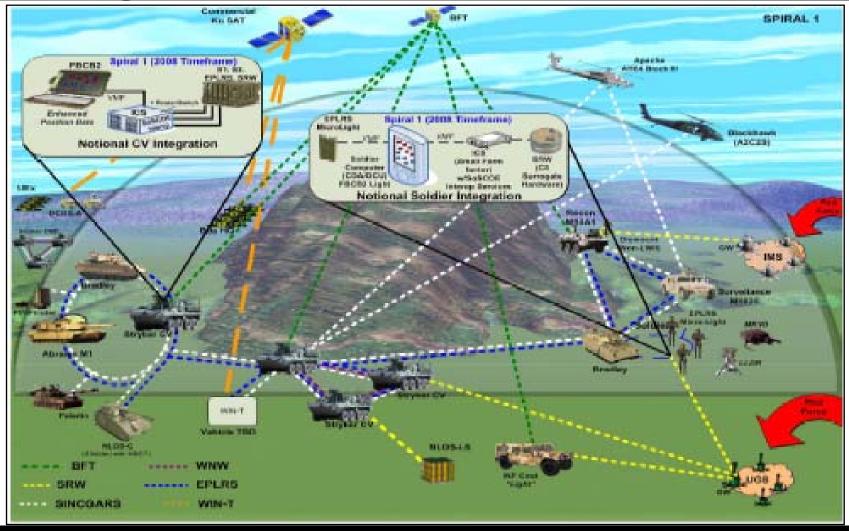


* Friedman, Thomas L. "The World Is Flat", Farrar, Straus and Giroux, 2005

© 2008 Carnegie Mellon University

Communications Among Systems – Fostering a Growing Interdependence and Integration

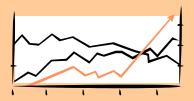




SE is a Partner in Addressing Both Approaches to Process Improvement



Data-Driven (e.g., Six Sigma, Lean)



Clarify what your customer wants (Voice of Customer)

Critical to Quality (CTQs)

Determine what your processes can do (Voice of Process)

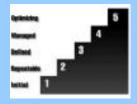
Statistical Process Control

Identify and prioritize improvement opportunities

Causal analysis of data

Determine where your customers/competitors are going (Voice of Business)

Model-Driven (e.g., CMM, CMMI)



Determine the industry best practice

Benchmarking, models

Compare your current practices to the model

Appraisal, education

Identify and prioritize improvement opportunities

- Implementation
- Institutionalization

Look for ways to optimize the processes



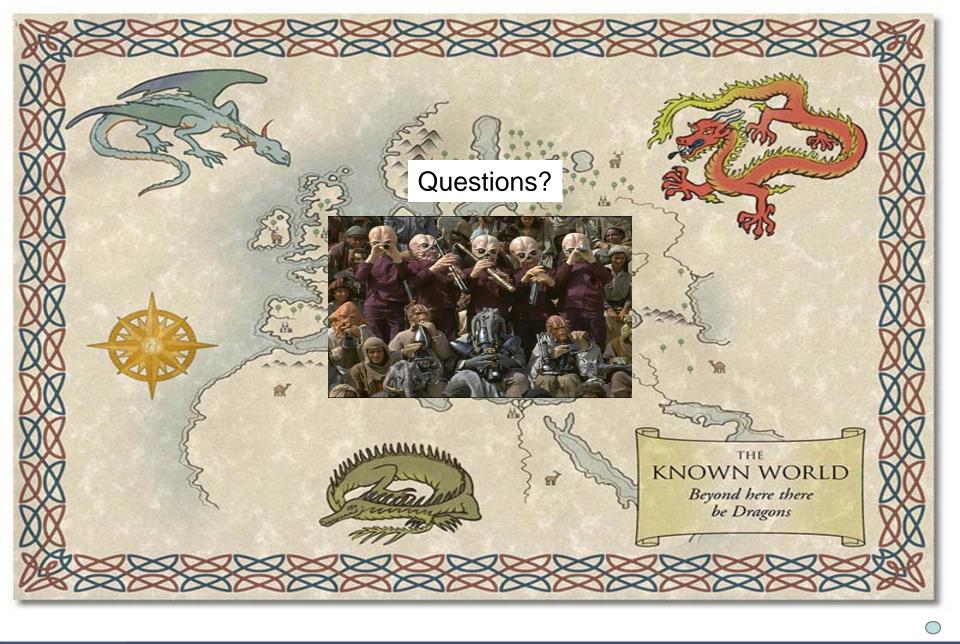
Systems and Software Engineering: Ten Trends

- Greater demands on systems and software engineers will stimulate growth in the field – nationally and internationally
- Industry/Gov't will increasingly focus on attracting, training and retaining systems and software engineering talent short and long run with emphasis on providing a Generation Y work environment
- Increased reliance on systems and software engineering processes and technologies to effectively manage the acquisition/"green" space
- The laws of Augustine's and Moore will continue to hold and will continue to be a forcing function to bring the fields of software and systems engineering closer together
- Improvements risk-reduction collaboration mechanisms will be significant enablers for increases in systems and software engineering communication and "decision velocity"

Systems and Software Engineering: Ten Trends

- Increased need for a large number of complex systems and systems of systems will lead to investments in research and technology
- Systems and software engineers will continually find way to innovative to reduce complexity
 - Increased importance of modeling and simulation
 - Increased reliance on architectures (top-down and bottoms-up)
 - Increased design for continuous evolution and deployment at all levels will occur
- Increased customer requests for system and software engineering support will occur earlier in life cycle
- •Shift of systems and software engineering focus from the platform to the networks and ground systems
- Process improvement will continue to be important







Recommended Readings



Buckman, Robert H. Building a Knowledge-Driven Organization. McGraw-Hill, New York, NY, 2004.

GAO Report: 08-467SP, Defense Acquisitions – Assessment of Selected Weapon Systems, March 2008

Chesbrough, Henry William. Open Innovation: The New Imperative for Creating and Profiting from Technology. Harvard Business School Publishing Corporation, Boston, MA 2003.

Drucker, Peter. Managing in the Next Society. Truman Talley Books, New York, NY, 2003.

Friedman, Thomas L. "The World Is Flat", Farrar, Straus and Giroux, 2005

Gates, William H. III "Business @ The Speed of Thought – Using a Digital Nervous System", Time Warner Books, 1999

Kurstedt, Harold and Pamela, Systems and Software Engineering Interfaces, Dealing with the Bumpy Roads, Participant Guide, March 2008

Malone, Thomas. The Future of Work: How the New Order of Business Will Shape Your Organization, Your Management Style and Your Life. Harvard Business School Publishing, Boston, MA, 2004. See http://ccs.mit.edu/futureofwork/

Nidiffer, Kenneth E. and Doland, Diana "Evolving Distributed Project Management", special issue <u>IEEE Software</u>, Sept/Oct 2005

Northrop, Linda. Ultra-Large-Scale Systems – The Software Challenge of the Future, Software Engineering Institute, June 2006

Rouse, William B. et al, *Understanding R&D Value Creation with Organizational Simulation*, Tennenbaum Institute, H. Milton Stewart School of Industrial & Systems Engineering, Georgia Institute of Technology, Atlanta, GA 30332-0205, Oct 2006

Wladawsky-Berger, Irving. "The Future of IT in an On-Demand World." IBM Server Group, Keynote address at OSBC 2005. Archived at http://www.itconversations.com/shows/detail495.html

0008 GOES-7 IR 08 30 OCT 91303 120100 01297 09305 04.00

